Assignment #1 / ENCE 335

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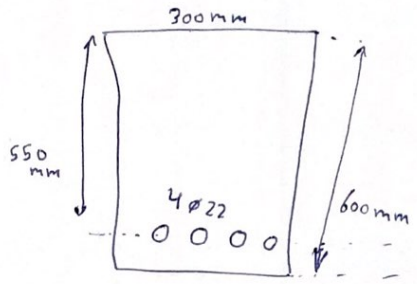
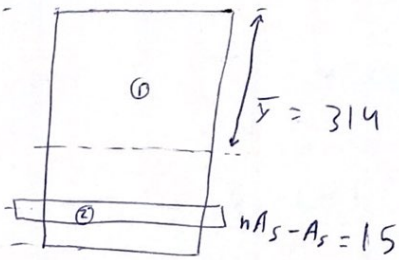
$f_s' = 28\ MPa$

$n = \frac{E_s}{E_c} = \frac{200}{4700\sqrt{28}} = 8$

(a)





$nA_s - A_s = 1520\ (7) = 10\,638\ mm^2$

$M_{cr} = ?$ Phase 1 Linear noncracking

	A_{mm^2}	$\bar{y}$	$A\bar{y}$
①	180000	300	
②	10638	550	

$\Sigma A =$

$\Sigma Ay = 59851076$

$\bar{y} = 314\ mm$

	I	Ad^2
①	54×10^8	3528×10^4
②	0	

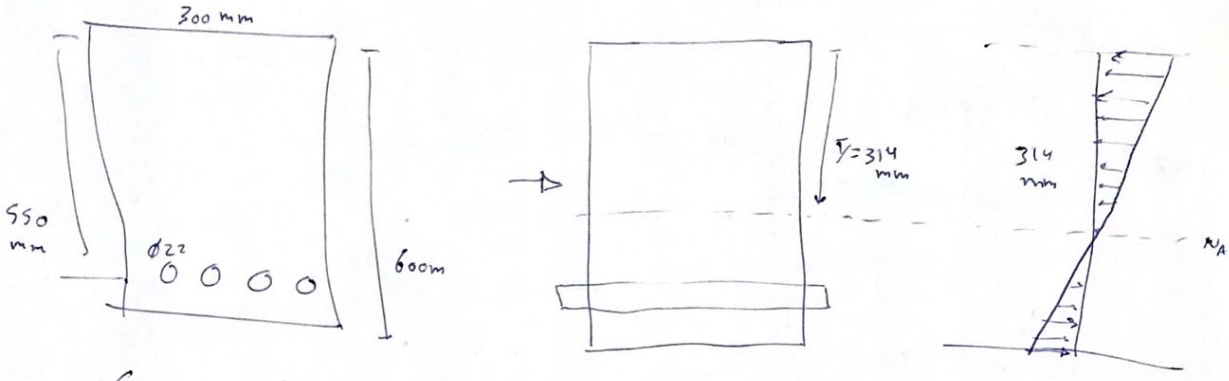
$\Sigma I + Ad^2 = 6.03\times10^9\ mm^4$

$f_r = 0.62\sqrt{28} = 3.28\ MPa$

$\sigma_{\text{when crack in Tension}} = \frac{(M_{cr})\,y}{I} = f_r$

$M_{cr} = \frac{f_r\ I}{y} = \frac{(3.28)(6.03\times10^9)}{600-314} = 69.155\ KN.m.$

$m = 55$ kN·m $< M_{cr}$.



$$\sigma_{max,C} = \frac{(m)\,\bar{y}}{I} = \frac{(55)\,10^6 \times (314)}{(6.03)\,(10^9)} = 2.864 \text{ MPa}$$

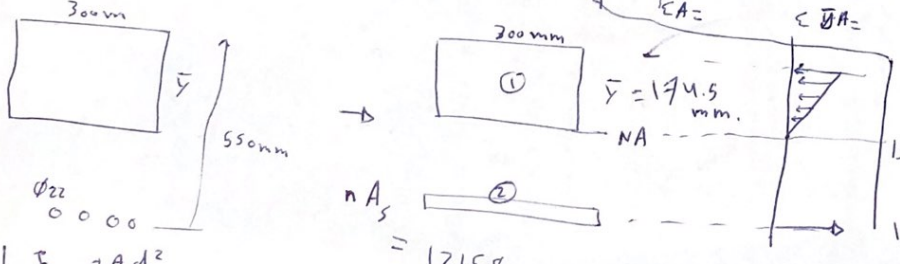
$$\sigma_{max,T} = \frac{(m)\,(600-\bar{y})}{I} = \frac{(55)\,10^6 \times (600-314)}{(6.03)\,10^9} = 2.6 \text{ MPa}.$$

~~σ_{steel}~~

$$\sigma_{steel} = n \times \sigma_{c,s} = 8 \times \frac{m\,(550-\bar{y})}{I} = \frac{8(55)10^6(550-314)}{6.03\times10^9}$$

$$\Rightarrow \sigma_{steel} = 17.22 \text{ MPa}$$

$m = 75$ kN·m $> M_{cr}$.



	A mm²	$\bar{y}$	$\bar{y}A$
①	$300\bar{y}$	$\bar{y}/2$	$150\bar{y}^2$
②	12158	550	6686944
	$\Sigma A =$		$\Sigma \bar{y}A =$

$$\bar{y} = \frac{150\bar{y}^2 + 6686944}{300\bar{y} + 12158}$$

$$150\bar{y}^2 - 300\bar{y}^2 - 12158\bar{y} + 6686944 = 0$$

$$150\bar{y}^2 + 12158\bar{y} - 6686944 = 0$$

$$\bar{y}^2 + 81\bar{y} - 44580 = 0$$

$$(\bar{y} + \quad)(\bar{y} - \quad) = 0$$

$$\bar{y} = 174.5 \text{ mm}$$

	$I + Ad^2$
①	$\frac{1}{3}(174.5)^3(300)$
②	$0 + 1714281040$

$$\Sigma I + Ad^2 = 2.2456 \times 10^9 \text{ mm}^4$$

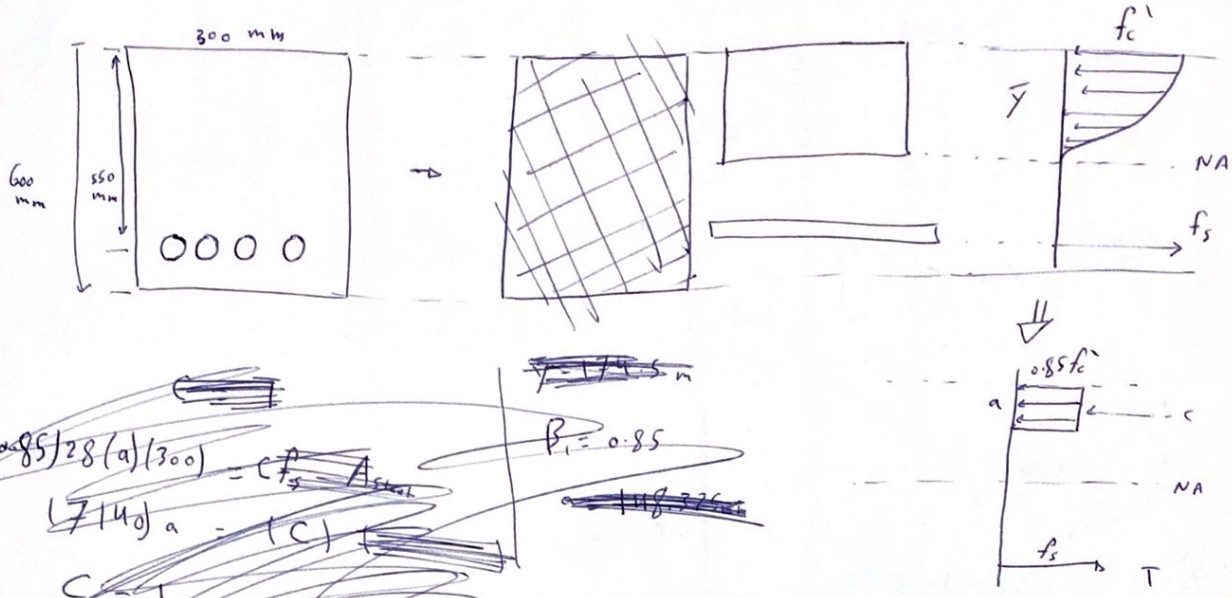
Phase 2 Linear Cracking.

$$\sigma_{max,C} = \frac{m\,\bar{y}}{I} = \frac{75\times10^6 \times 174.5}{2.2456\times10^9} = 5.828 \text{ MPa}.$$

$\sigma_{max,T} = 0$.

$$\sigma_{steel,T} = n\,\sigma_{c,s} = \frac{(8)\,75\,(375.5)}{(2.248)(1000)} = 100 \text{ MPa}.$$

to found nominal moment capacity (Phase 3 : nonlinear (cracking).



$\beta_1 = 0.85$

$(0.85) 28 (a) (300) = C$

$(7140)\, a = (C)$

$C = 0.5904\, a$ N

$M_n = (0.85) f_c' (a)(300) \left[550 - \frac{148.325}{2}\right]$

$M_n = 425.4$ kN.m

$M_n = 504$ kN.m

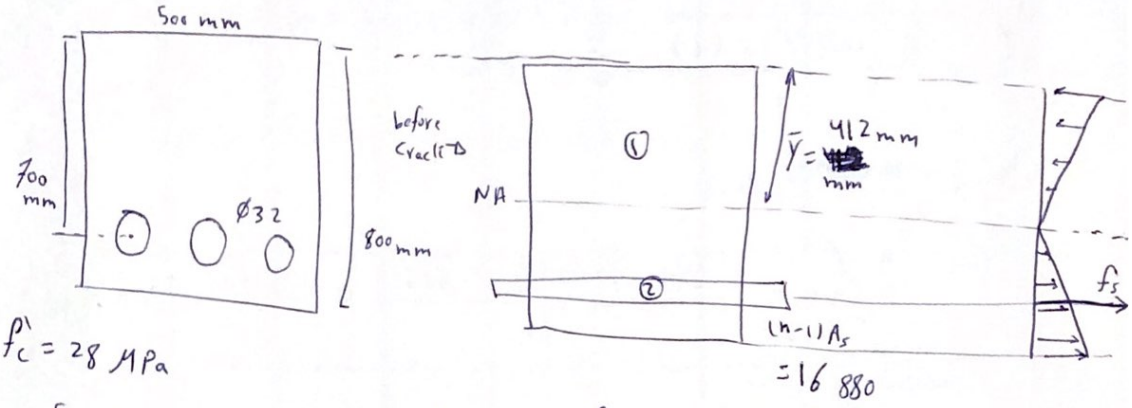
$$a = \frac{A_s f_y}{(0.85) f_c' B} = 89.4 \text{ mm}$$

$$M_n = (0.85) f_c' \, a \, B \left(D - \frac{a}{2}\right)$$

$$= f_y A_s \left(D - \frac{a}{2}\right)$$

$M_n = 322$ kN.m

(b)



$f'_c = 28\ MPa$

$(n-1)A_s = 16\,880\ mm^2$

$n = \frac{E_s = 200}{4700\sqrt{28}} = 8$

$f_r = 0.62\sqrt{28} = 3.28\ MPa$

	A_{mm^2}	$\bar{y}$	$A\bar{y}$
①	400 000	400	
②	16880	700	

$\Sigma A =$ $\Sigma A\bar{y} =$

$\Rightarrow \bar{y} = 412\ mm$

	$I + Ad^2$
①	$21.4 * 10^9$
	$0 + 16880(288)^2$

$\Sigma\ I + Ad^2 = 22.8 * 10^9\ mm^4$

$M_{cr} = \frac{f_r\ I}{\bar{y}}$

$\Rightarrow M_{cr} = \frac{(3.28)_{MPa} * (22.8 * 10^9)_{mm^4}}{412\ mm}$

$M_{cr} = 181.44\ KN.m$

$m = 150\ KN.m < M_{cr}$ ∴

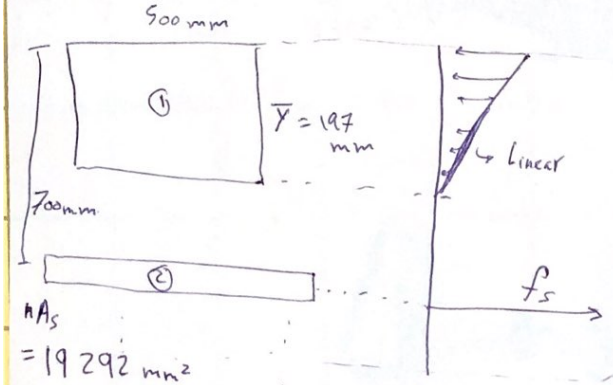
$\sigma_{con,c} = \frac{(150)10^6 * 412}{I} = 2.71\ MPa.$

$\sigma_{con,T} = 2.55\ MPa$

$f_s = n\,\sigma_{c,steel} = \frac{(8)(150)(10^6)(700 - 412)}{22.8 * 10^9}$

$f_s = 15.16\ MPa$

$m = 200\ KN.m > M_{cr} \Rightarrow$ Linear Crack ∴



	A	$\bar{y}$	$\bar{y}A$
①	$500\bar{y}$	$\bar{y}/2$	$250\,\bar{y}^2$
②	19292	700	13 504 400

$\Sigma A = 500\bar{y} + 19292$. $\Sigma \bar{y}A = 250\bar{y}^2 + 13\,504\,400$.

$\bar{y} = \frac{250\bar{y}^2 + 13\,504\,400}{500\bar{y} + 19\,292}$

$\Rightarrow 250\bar{y}^2 + 19\,292\,\bar{y} - 13\,504\,400 = 0$

$\bar{y}^2 + 77\bar{y} - 54018 = 0 \Rightarrow \bar{y} = 197\ mm.$

		$I + Ad^2$
$d = \bar{y}/2$	①	$\frac{1}{3}(197)^3(500) = \square$
$d = 503$	②	$0 + Ad^2 = \square$

$\Rightarrow \bar{I} = \Sigma\ I + Ad^2 \Rightarrow \bar{I} = 6.1553 * 10^9\ mm^4$

when $m = 200\ kN.m > M_{cr}$

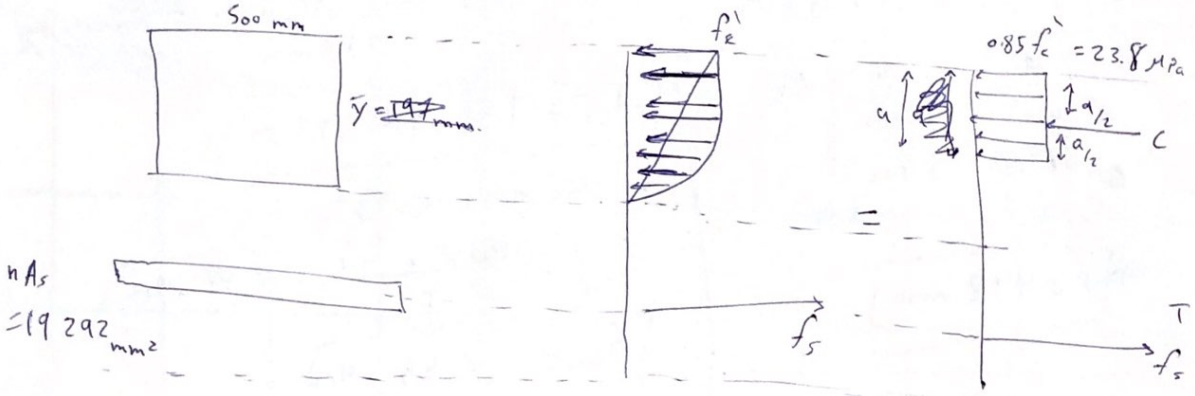
$$\sigma_{con.,C} = \frac{1200,10^6 * 197}{\bar{I}} = 6.4\ MPa$$

$\sigma_{con.,T}$ = ~~1200,10^6~~ Zero

$$f_{steel} = n\,\sigma_{con,T\ at\ bars} = (8)\ \frac{(200)10^6 * 503}{\bar{I}} = (16.34\ MPa)\,8 = 130.73\ MPa.$$

$M_n = ?$

nonlinear & Phase 3:



~~$a = \beta_1 \bar{y} = (0.85)\ 197 = 167.45$ mm.~~

$$a = \frac{A_s f_y}{0.85 f_c' b}$$

$$\beta_1 = 0.85 - \left(\frac{f_c' - 28}{7}\right) 0.05 = 0.85$$

$a = 85$ mm

$$M_n = (T) * (700 - a/2) = (C) * (700 - a/2)$$

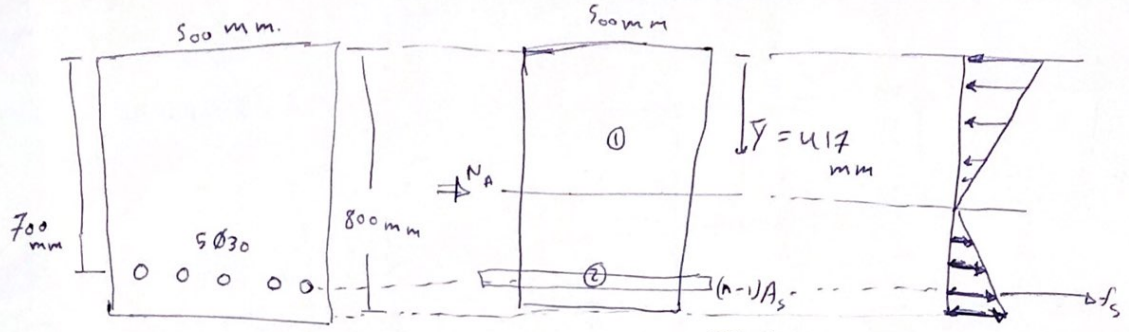
$$= (0.85) f_c' (a)(500)\ [616.275]$$

~~$M_n = 1228$ kN.m~~

$M_n = 665$ kN.m

(c)

Phase 1



$= 24727.5 \text{ mm}^2$

$f_s' = 28 \text{ MPa}$

$f_r = 0.62\sqrt{28} = 3.28 \text{ MPa}$

$n = \frac{f_s}{4700\sqrt{f_c'}} = 8.$

	A mm^2	$\bar{y}$	$\bar{y}A$	$I + Ad^2$
①	(500)(800)	400		$\frac{(800)^3 500}{12} + (500)(800)(17)^2$
②	24727.5	700		$0 + 24727.5\,(283)^2$
	$\Sigma A =$	$\Sigma \bar{y}A =$		$\Sigma I + Ad^2 = \bar{I} = 23.4 \times 10^9 \text{ mm}^4$

$\bar{y} = 417$ mm / direct from Calculator.

$M_{cr} = \frac{(f_r)\, I}{y_o}$, $y_o = 800 - 417$

$M_{cr} = 200 \text{ kN.m}$

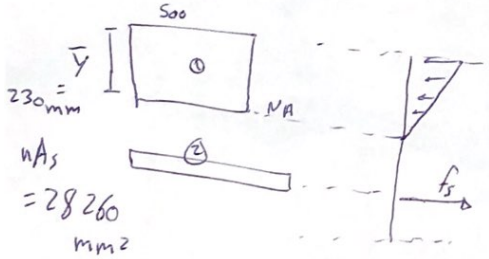
$m = 140 \text{ kN.m} < M_{cr}$

$\sigma_{con.,c} = \frac{(140)10^6 * (417)}{\bar{I}} = 2.5 \text{ MPa}$

$\sigma_{con.,T} = \frac{140 * 10^6 * 383}{\bar{I}} = 2.3 \text{ MPa}$

$f_s = n\,\sigma_{con.T\ of\ bars} = \frac{(8)(140)10^6 * (283)}{\bar{I}} = 13.5453 \text{ MPa}.$

$m = 240 \text{ kN.m} > M_{cr}$



	$A\ mm^2$	$\bar{y}$	$A\bar{y}$	$I + Ad^2$
①	$500\bar{y}$	$\bar{y}/2$		$\frac{1}{3}(230)^3 500$
②	28260	700		$0 + (28260)(470)^2$
	$\Sigma A =$	$\Sigma A\bar{y} =$		$\bar{I} = 8.27 \times 10^9 \text{ mm}^4.$

$\bar{y} = \frac{250\bar{y}^2 + 19782000}{500\bar{y} + 28260}$

$250\bar{y}^2 + 28260\bar{y} - 19782000 = 0$

$\bar{y}^2 + 113\bar{y} - 79128 = 0$

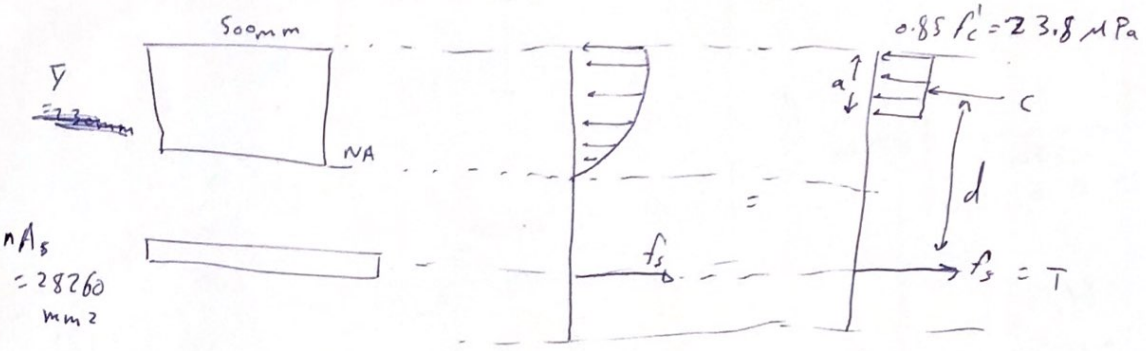
$\bar{y} = 230 \text{ mm}$

$\sigma_{con.,c} = \frac{(240)10^6 * 230}{8.27 * 10^9} = 6.675 \text{ MPa}$

$\sigma_{con.,T} = 0$

$f_s = n\,\sigma_{con.\ of\ bars} = \frac{(8)(240)10^6 * (470)}{8.27 * 10^9} = 109 \text{ MPa}.$

to find M_n → Phase (3) ∴ non linear.



$a = \bar{y} \beta_1 = 195.5 mm$

$\beta_1 = 0.85 - 0.05 \left(\frac{f_c' - 28}{7} \right)$

$= 0.85$

$a = \frac{A_s f_{y,s}}{0.85 f_c' (500}$

$= 124.7 mm$

$C = (a)(500)(0.85) f_c'$

~~$M_n = C d = 1401 kN.m$~~

$M_n = C d = 946 kN.m$